UNITED STATES DEPARTMENT OF THE INTERIOR
Fish and Wildlife Service
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PROBLEM STATEMENT
SALMON AND STEELHEAD FRESHWATER HABITAT
PUGET SOUND AND OLYMPIC PENINSULA

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FRESHWATER HABITAT REQUIREMENTS OF ANADROMOUS SALMONIDS

Salmon and steelhead production in streams is dependent upon 1) access to the sea 2) adequate quantity and quality of water 3) suitable gravel for spawning and egg incubation 4) food supply and 5) shelter.

Access to the sea: Anadromous fishes spawn in freshwater, and the young, after hatching and emerging from the gravel, spend varying periods of time in the streams or lakes before migrating to salt water. The residence time in the estuaries and ocean varies as do the patterns of migration. The adult fish return to freshwater, usually in fixed patterns by races; some spawn within hours and others, such as summer-run steelhead, spawn after months in the stream. Since adult salmon largely sustain themselves on stored energy once they leave the marine environment, even temporary delays in upstream passage, caused by low water or pollution blocks, can be as catastrophic to effective reproduction as a total block caused by a dam.

Adequate quantity and quality of water: Generally, relatively stable flows of well-oxygenated, unpolluted, cool (50^{0} - 60^{0} F) water filling a natural stream channel provide the habitat essential for migration, spawning, egg incubation and rearing of salmonids. Such a flow regime includes nominal flooding or freshets required for migration. Structure and function of such an ecosystem is readily altered by pollution, water withdrawal, flooding, erratic flows below hydroelectric installations, or a combination of these and other influences.

Pollutants may be directly toxic to fishes and produce catastrophic fish kills. Certain chemicals used in insect control and acids used in industries belong to this group. Other chemical additives -- road salt, oil, heavy metals -- acting singularly or in combination, even at low levels, can have an equally devastating, though unnoticed, effect. Or pollutants may have an indirect effect by decreasing the amount of oxygen in the water, thereby resulting in an oxygen deficiency for fish. Barnyard drainage and logging slash left in streams fall into this group. A third type of pollutant -- solid particles -- act more indirectly than the other two groups. Particles of silt, sand, clay and mud washed into streams from erosion on the land smother spawn, spawning sites, cover, pools, and food organisms. And with the channel filled with such particles, the cutting power of flood waters is spread outward, thereby widening the channel and causing the minimum flows of summer to warm more.

Interactions between factors that make up the stream environment represent complex relationships. One change inevitably leads to another. With warmer water temperatures, for example, salmonids species tend to be usurped by less desirable fish species. The continuum of interactions is not necessarily cumulatively depressive on salmon productivity. Streambed silting, clearly asthmatic to salmon spawning and food organisms, requires periodic cleansing by high water velocities, not necessarily flood flows, if the habitat is to be maintained. Moreover, an addition of organic materials well below the purifying potential of infertile streams can act as fertilizer in boosting food production for salmonids. On the other hand, it is clear that the ecological integrity of salmon habitat can be stressed by cumulative, subtle interactions and changes over time as well as obvious catastrophic channelization, impoundment, and alternating stranding, desiccation and flushing due to fluctuating discharges below dams.

Gravel for spawning and egg incubation: Spawning sites are usually located on gravel areas of streams where there are either riffles or upward pressure of spring seepage which contributes to a relatively loose pack of such materials. Water must percolate through the redd and gently aerate the eggs to assure development and hatching. The general criteria for water velocity suitable for spawning is 1.0 to 3.0 fps. It is essential that the eggs not be smothered by sediments, dislodged by floods, destroyed by molar action stemming from excessive bed load movement, or desiccated due to fluctuations in water level. The rate of incubation is dependent on water temperatures, but generally requires an extended and hazardous period of two to four months.

Food supply: Almost all unpolluted streams possess a supply of natural food organisms appropriate for the subsistence of the fishes of that locale. Abundance of food supply depends on regional variations in soil fertility, climate, and stability of the stream habitat. Salmonid streams, because they are cold water habitat generally draining relatively infertile land areas, can only be ranked in the low range of fertility characteristics. This is a natural condition and no cause for concern, except as to how such inherent low productivity represents constraints to salmon production and allows little error in depressing limited productivity as a result of environmental degradation.

Substrate and water velocity are factors controlling the types and abundance of food organisms within the productivity bounds. The greater the water velocity, the less abundant are the free-swimming forms and the more prominent are the nymphs and larvae adapted to clinging on rock substrate. Salmonid feeding activity, like food supply, is linked with discharge and velocity, as is fish distribution within the constraints of the physical environment. Essentially, current transports the food organisms from place of production (riffles) to locations where fish can reside.

Shelter: Above an "extinction" flow level, velocity is the major factor controlling animal communities in streams. Current is largely a mechanical restraint to salmonid survival except for reproduction and migration. Shelter allows salmonids to maintain themselves in currents bearing the greatest drift of food.

Shelter may consist of water depth, submerged logs and rocks, etc. Salmonids generally occupy a limited area, providing shelter or micro-habitat, which provides focal point residency in feeding and resting. Newly-hatched salmonids can only tolerate nearly still water. As the fish grow, they are associated with velocities and depths in proportion to body size, shifting to faster, deeper waters and larger territories as they become larger.

Efficiency of occupancy, particularly as it relates to food gathering and energy expenditure, depends on the spatial dimensions of the channel in relation to where food and cover come together, creating micro-habitat.

HABITAT DEGRADATION

In nearly all journals of Pacific Northwest explorers, the writers remarked on the abundance of salmon and steelhead. With the invention of the tin can during the mid-1800's, the fishing industry began intensive exploitation. Catches of all species of salmon in Puget Sound have ranged from a high of over 39 million fish in 1913 to a low of just over one million fish in 1944. Some of the stocks have been increasing in recent years, largely due to increased hatchery production. At the same time some of the natural stocks have become depleted or eliminated, due to degradation of the environment as well as overfishing.

Northwest streams originally contained a complex variety of characteristics which resulted in a highly variable complement of salmonid populations. Over the years, there has been a gradual but continuing loss of habitat as a result of watershed alterations, construction of dams and reservoirs, changes in stream channels, and industrial and residential development. To the casual observer, overharvest is readily understandable, whereas effects from man-related disturbances to salmon habitat may be masked by natural climatic and population fluctuations, or cumulative subtleties of various impacts operating over long periods of time.

<u>Effects of watershed alteration</u>: The most significant watershed alteration over the past has resulted from logging operations. The sheer magnitude of commercial timber operations in the Pacific Northwest illustrates the problem -- 65 million acres of land and 250,000 miles of logging roads in Idaho, Alaska, Oregon, British Columbia and Washington.

Table 1. Major limiting factors on anadromous fish in Puget Sound and coastal watersheds. (For greater detail, see narrative summary, Appendix II.)

Basin or Sub-region	Flooding	Low summer flows	Natural barriers	Man-made barriers	Erratic stream flows	Unstable streambed	Production area lost	Water quality	Temperature
Nooksack	X	X	X		X	X	X	X	X
Skagit	X	X	X	X	X		X		
Stillaguamish	X	X	X					X	X
San Juan		X							
Whidbey		X							
Snohomish	X	X	X	X			X	X	X
Cedar		X		X			X	X	X
Green	X	X		X			X	X	X
Puyallup	X	X		X	X	X	X	X	X
Nisqually	X	X	X	X	X				
Deschutes	X	X	X				X		
Shelton	X	X	X					X	X
Kitsap	X	X	X			X	X	X	X
Hood Canal	X	X	X	X	X	X	X		
Quilcene	X	X	X		X		X		X
Elwha-Dungeness	X	X	X	X				X	
Lyre-Hoko	X	X		X		X	X		
Soleduck-Hoh	X				X				
Queets-Quinault	X	X	X	X	X				
Lower Chehalis	X	X	X	X	X		X	X	X
Upper Chehalis	X	X	X	X	X		X	X	X
Willapa	X	X	X	X	X		X		X

Logging practices and potential impacts to fisheries can be categorized as follows:

1. <u>Logging road construction and maintenance</u>: (a) abnormal siltation resulting in decreased intragravel survival of salmon eggs and reduced post-emergent fitness of fry, reduction of food organisms and filling of intragravel spaces used by fry as shelter; (b) abnormal suspended sediment (turbidity) resulting in physical abrasion of respiratory structures of fish and aquatic insects and reduced photosynthesis of algae; (c) sluiceouts and landslides in steep headwater streams due to alterations in natural drainage patterns; (d) blocks to migrants because of poor culvert placement.

2. <u>Tree removal</u>: (a) increased streamflows and rapid attainment of peak flows from large clearcuts during freshets, resulting in additional streambed scour with loss of salmonid eggs, fry and food organisms, summer water temperatures reaching lethal limits, and depression of winter temperatures; (b) logging across and through streams causing large amounts of fine organic material to enter the stream, exerting an excessive biological oxygen demand; (c) slash debris left in streams causing erosion of embankments, logjams that block migration and cover spawning and rearing areas.

3. <u>Application of chemicals</u>: Fertilizers are used to supplement soil nutrient deficiencies, herbicides to suppress undesirable species, and insecticides to control insect pests in timber management.

Aside from the now-outlawed insecticides, such as DDT, there are few, if any, definitive studies that show application of presently-registered chemicals as presenting a clear-cut threat to salmon habitat under proper use. However, scientists feel there is need for additional research in this area.

4. <u>Log storage and transportation</u>: Demonstrated impacts are dislodgement of bark and "leachates" which exert both a chemical and biological oxygen demand, besides adding color-producing substances to the water. Douglas fir leachates have been identified as toxic to rainbow trout and chinook salmon fry.

From the turn of the century until about 1925 "splash dams" were used extensively in Washington for moving logs downriver to the mills at tidewater. These log crib dams were frequently 50 feet high and often blocked salmon and trout migration. The Chehalis River and its tributaries alone had over 55 dams which were later determined to block over sixty percent of the river's spawning and rearing areas. Log driving also caused erosion and gouging of gravel, bark deposition and, no doubt, killed salmonid eggs as well.

Another significant, though less extensive, watershed alteration involves water abstraction either for irrigation or municipal water supply. Removal of water from streams during the critical low-flow summer months inevitably reduces rearing capacity based on the singular precept that the smaller the size of the world in which fish are forced to live, the fewer the number of fish there can be. Interactions involve more than living space, however. With less volume of flow, the remaining flow is subject to greater warming by solar radiation. A water volume sufficient to cover the streambed will not warm up as quickly or as much as if the flow is limited to a trickle percolating through and around sun-baked rocks and gravel. Moreover, warm water is not capable of holding as much oxygen as cold water. Return of warm, probably enriched, irrigation flows, possibly contaminated with harmful pesticides and herbicides as well, accentuates the change from cold water salmonid habitat to less exacting habitat favoring other fish species. Other fish species, through predation and direct and indirect competition for food and space, exert an additional depressant on salmonid productivity.

The diversion of water, and consequently juvenile fish, from streams by unscreened ditches or pumps is a critical problem during outmigration. Today, extensive use is made of screening devices to prevent this loss, but the sheer magnitude of water withdrawal, which continues to grow dramatically, is such that not all intakes and diversions are screened. In addition, upstream migrants can be impeded or stopped due to less water in natural channels.

Dams and reservoirs: One of the most dramatic changes, often causing a complete loss of the salmon and steelhead habitat, is the series of dams which has been completed in the last 70 years. Unless located above natural fish-passage barriers, these projects interrupt and usually block fish migration. Moreover, they have a strong tendency to disrupt migratory timing due to alterations in the natural hydrological regime. Spawning grounds are inundated. Downstream migrants suffer mortalities in passage over spillways and through turbines, and also undergo greater predation in reservoirs as a result of the buildup of predator fishes in such habitat.

Less appreciated is that reservoir tailwaters differ from natural rivers in two respects. First, reservoirs act as sediment traps. Also, if water is released from the surface, the reservoir is a nutrient trap and heat exporter, whereas if water is released from near the bottom, the reservoir may be a heat trap and nutrient exporter. Second, arrest of sediment and gravel transport in reservoirs results in vastly increased sediment and gravel transport potential of the discharge.

These changes affect not only river morphology and metamorphosis, but also the aquatic ecosystem. Uniform channels with monotonous "armored" substrate tend to develop below dams as a result of the increased erosion potential of the discharge and because of reservoir entrapment of gravel from upstream. Thus, compaction and cementation of spawning gravel can be added to the alternating stranding, desiccation and flushing of fish and organisms that characterizes fluctuating discharges below dams. Contradictorily, as well, such habitat can be seasonally plagued by excessive siltation and turbidity. Many reservoirs lack storage capacity in relation to annual inflow. When at design pool level, suspended soil particles settle out. However, when the reservoirs are severely drawn-down, generally in fall and winter, the deposits can readily be flushed into the tailwater. Generally, too, water is released from the surface of these smaller reservoirs, thereby warming downstream temperatures in summer or early fall.

Effects of industrial and residential development: Industrial and residential development usurps water that otherwise would be available for fish production, with supply systems usually developed in the upper valleys and mountains. The actual industries and residences are frequently developed in the flood plains and deltas of the streams themselves.

In the more heavily populated and industrialized areas, major rivers and/or their estuaries are encroached upon by piers, docks, revetments, fills, roads, bridges, buildings. Sometimes even small tributaries or independent drainages have been converted to fetid, scum-filled, concrete-encased drain ditches. The natural vegetation is literally paved-over with buildings, shopping centers, gutters, sidewalks, driveways, cars, completely disrupting the natural hydrological regime. Flooding and drought are more frequent and severe, erosion accelerated, and water quality depressed. Urban-industrialized areas represent some of the most intensively transformed segments of the earth's surface. Salmonids would long ago have become extinct if more of the habitat had become so massively usurped; in less settled areas the degradation threat lies in degree, not kind.

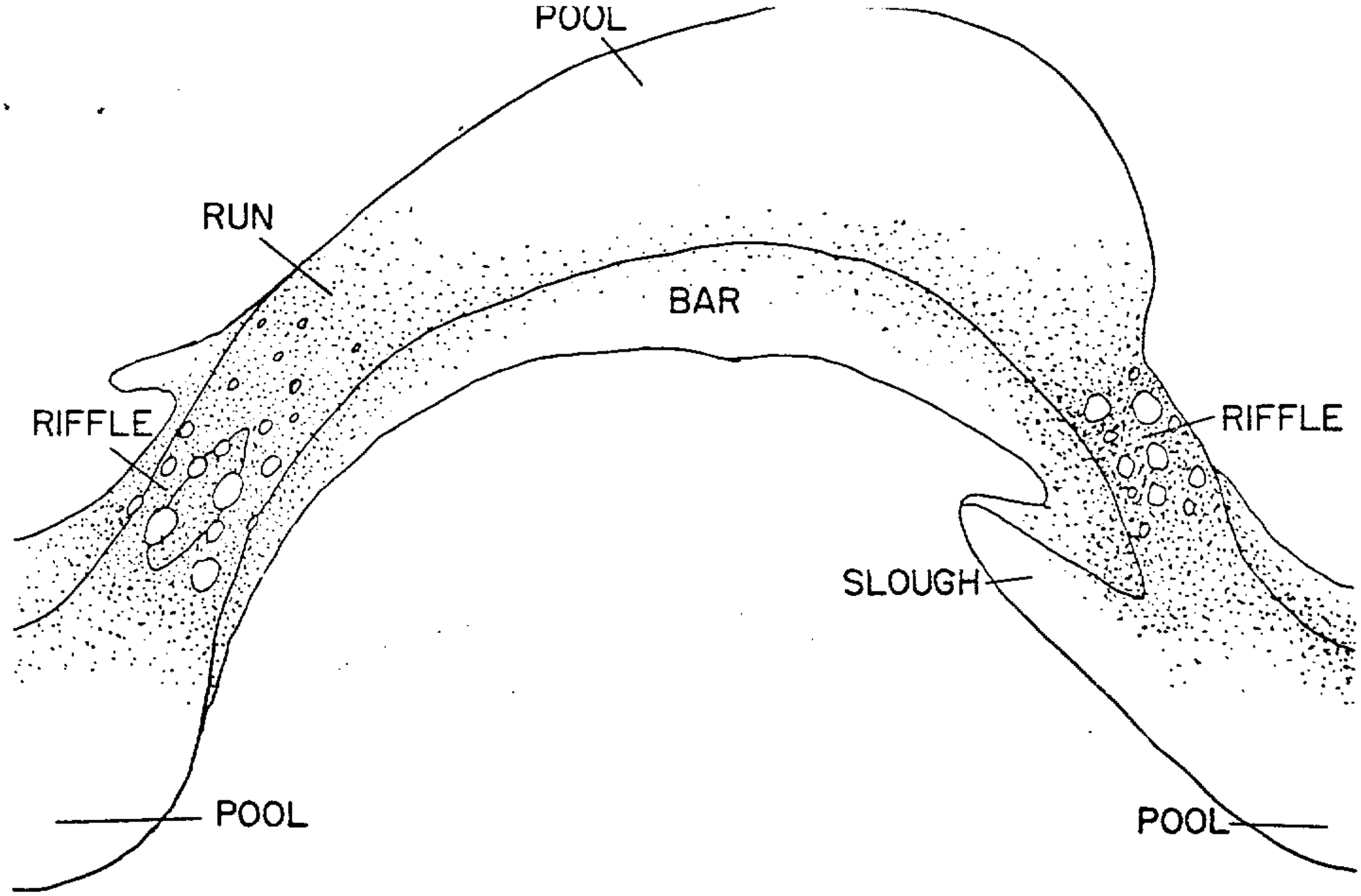
<u>Effects of channel changes</u>: Aside from the construction of reservoirs in mountain areas to help in control of natural and man-induced flooding of flood plains, where man largely lives and works, channelization (straightening, relocating, dredging) and diking of streams has been heavily relied on in preventing flood damage to man's residences, farm lands, factories, roads, bridges, utilities. Such flood control measures generally have devastating impact on salmonid habitat. Why this is so can best be answered by asking what a stream is.

One thing that it is <u>not</u> is an unchanging and static timeless watery world of perfect order. A stream is always changing, yet always striving toward the perfect order. This perfect order is the equalization of energy dispersal along its entire length. A change in discharge, for example, produces adjustment in width, depth, slope, velocity. Always, regardless of whether the change is large or small, the adjustment is toward a state of energy balance.

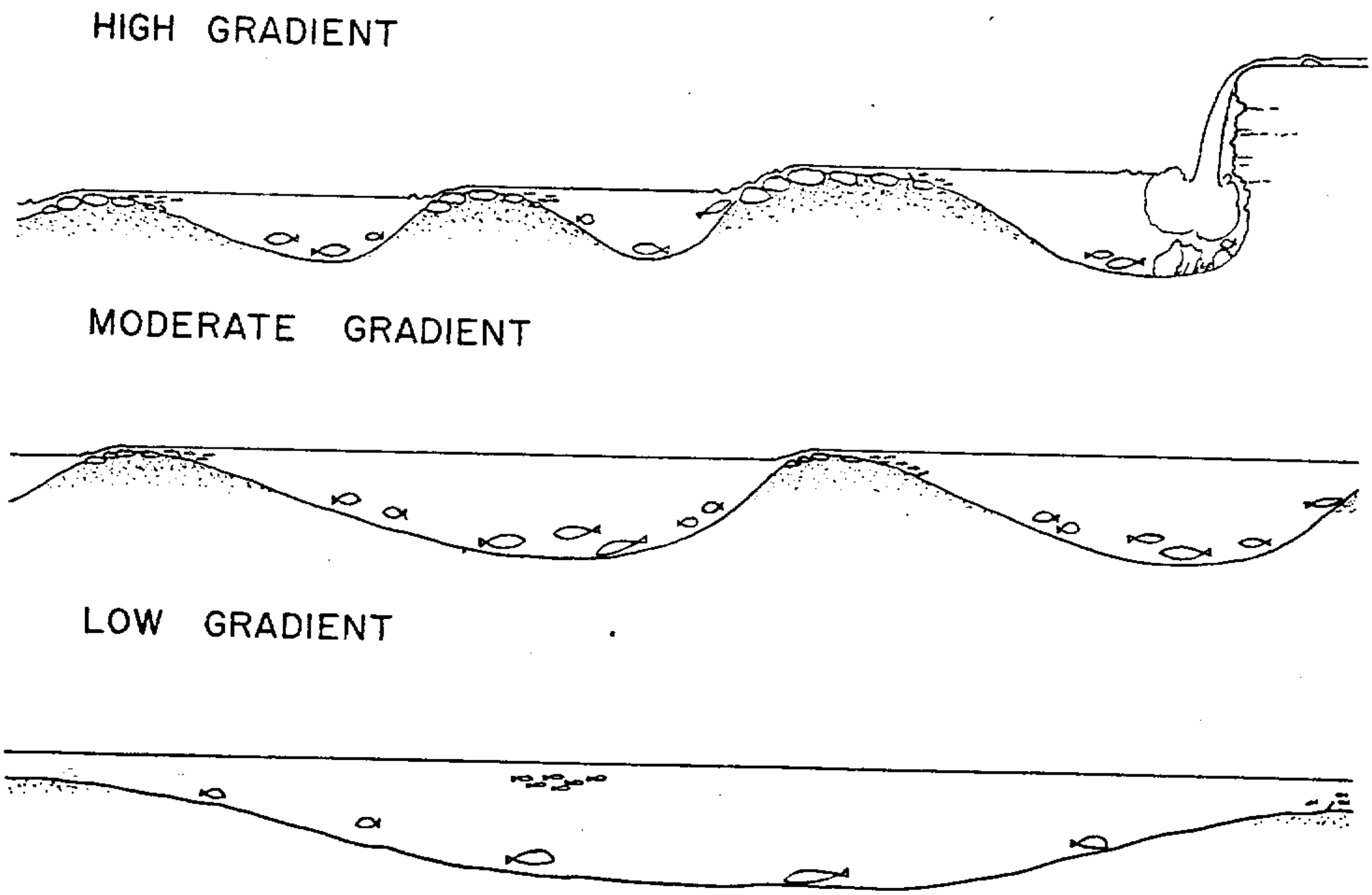
The flow of water carves a wavy course. This undulation we recognize in the flat plane of the horizon as meandering. Viewed from top to bottom, we see this as the pool-rapid, pool-riffle, or pool-mud flat sequence, depending on the gradient and the nature of the substrate. These hills and valleys of natural streambeds are the results of the underlying order in equalizing the energy in current. With predictability, the flow wanders from one side of the channel to the other, gouging out pools at the outside of the bends and building gravel bars on the inside.

What we have, then, in a natural stream channel considered from headwater to mouth, bank to bank, top to bottom, hour to hour, season to season, is a diversity of habitats. There is fast water, slow water, main waters, back waters, riffles, pools -- in fact, all the little nooks (microhabitat) and larger crannies (pools) that provide living space for fish and their food organisms.

Clearly, an optimum stream channel for salmonids doesn't just happen. Channels evolve over long periods of time as the cutting power (energy)



A meander in a stream and how it contributes to diversity.



Lineal diversity in a stream and its relation to gradient.

of the current gradually adjusts to the counter forces of channel resistance, course curvature, vegetative binding of soils, average rainfall and other interrelated variables. The resulting adjustment represents a balance between all the physical and biological forces involved. At its climax it is most diverse in habitat in optimizing salmonid productivity. Extreme flooding invariably results in a violent reaction from order (stability) to disorder (disfunction) as the stream, once again, reaches toward a state of energy balance.

The impact of channelization also destroys the diversity of habitat so long in evolving and so essential to salmonids. The effects of channelization on 46 streams outside the state of Washington show substantial and prolonged decrease in salmonid populations (44% to 94% declines in weight and number).

Indiscriminate removal of riverbed materials, particularly gravel, can be equally devastating by reducing spawning areas and causing continuous and excessive bed load movement. Egg mortalities are extreme where shifting gravel conditions occur. The loss of suitable gravel from existing bars forces superimposition of eggs in remaining areas. Moreover, salmonid fry and fingerlings can be trapped and lost in the pits and pockets left by gravel excavation of river banks at low water.

STATE AND FEDERAL PROTECTION LEGISLATION

The gradual but cumulative loss of salmon habitat over the years did not go entirely unnoticed, as reflected in the legislation passed to prevent or mitigate such loss.

Stream flow alterations:

1. Dams, diversions, and other barriers:

   (a) State laws - The Revised Code of Washington (RCW) 90.28.170, enacted in 1911, allowed anyone to construct a dam in streambeds with no mention of protection to anadromous fishery resources. RCW 75.20.060 and 77.16.210 state that fishways are required in dams or, as stated in RCW 75.20.090, that if fishways are impractical, fish hatcheries may be provided in lieu thereof. These laws originated in 1949 and were modified in 1955, but there is evidence that legislation requiring fishways at dams dates to at least 1893. Such response was generally characterized by too little, too late, as illustrated by the construction of the first of two dams on the Elwha in 1913, which effectively blocked off all but five miles of the lower river to salmon and steelhead. Negotiations for fish passage facilities in the dam were begun by the state fish commissioner in 1911, but none were ever built, and loss of the substantial runs of salmon to the 90 miles of upstream habitat was mitigated only in 1975, with a downriver artificial spawning channel. Several other major dams have blocked large runs of salmon and steelhead.

There are numerous smaller dams and diversions which totally, or partially, block access to upstream areas which, in the aggregate, once contributed significantly to salmonid abundance.

The other side of the coin is that the measures effected for correcting or circumscribing draw-backs of dams frequently fell short of their mark. Salmon runs are acknowledged as depressed below original levels in the Baker and White rivers and the North Fork of the Skokomish River despite efforts to ameliorate impacts of causative structures. At the Baker River dams, for example, every attempt was made to perpetuate the runs, including a trap-and-haul system for adults, artificial spawning beaches, and passage facilities for smolts. Preimpoundment return to the river averaged 10,400 sockeye in the period 1905-1927, but subsequently declined to less than one-half of this from 1928 to 1953, following construction of the first dam. The decline has continued in more recent years. There are no laws which specifically address efficacy of by-pass measures, although RCW 75.20.060 and 77.16.210, which require fishways, may inherently do so.

A less familiar law, RCW 90.24.202, states that anytime a group of landowners join to control the outflow of a lake on which they abut, they must provide a fish ladder or similar device. The fact that most raised smaller lakes are without such facilities speaks for itself. An unusual law, RCW 90.28.160, enacted in 1891, allowed any landowner the right to construct a fence across all unmeandered streams. This would, of course, be subject to approval under the Hydraulics Act RCW 75.20.100 today, but there are instances of existing fences blocking anadromous fish, such as on Jimmy-Come-Lately Creek in Clallam County.

(b) Federal laws - There are three ways in which current federal laws extend to the construction and placement of dams and diversions. First, smaller activities of this sort located in navigable waters fall under the jurisdiction of the U.S. Army Corps of Engineers (Corps) via Section 10 of the Rivers and Harbors Act of 1899. However, this act was not expanded to include environmental considerations until 1970. Another applicable law is Section 404 of the Federal Water Pollution Control Act. There are two avenues of implementation.

One way is that the Corps has the final say in the permit process of any activity affecting navigable waters (after July 1, 1977, Section 404 includes all navigable waters to their headwaters and adjacent wetlands) proposed by any local government or private entity. Under the Fish and Wildlife Coordination Act, originally passed in 1934 but amended many times since, several agencies may provide comment on the effects of the proposed project on fish and wildlife. These agencies include U.S. Fish and Wildlife Service (USFWS), National Marine Fisheries Service (NMFS), and the chief official of the state resource agency concerned with fish and wildlife. These agencies are informed of the permit by Corps Public Notices.

The other way is that if a proposed project is large, "significantly" damaging to the environment, or if there is a great deal of public controversy surrounding the project, the Corps may decide that an Environmental Impact Statement (EIS) must be prepared under the National Environmental Policy Act of 1969. Agency comments on a Public Notice may include recommendations for an EIS. If this happens, the same agencies noted above review the draft statement as to the adequacy of the statement or as to the issues themselves. This EIS is then submitted to the Council on Environmental Quality at least 15 days prior to the public hearing. Smaller diversions and dams, especially those owned by private individuals, are generally exempt from such review.

The second area of federal-state interfacing involves major public works projects begun since 1969, including most Corps dams, which are reviewed under the National Environmental Policy Act (NEPA). Since this is a recent act, most of the projects in Western Washington were completed before an EIS was required (both the Corps review of small projects and NEPA contain grandfather clauses). Congress mostly determines the rules used in deciding when, where and how a major public works project using federal funds is to be developed. There is usually no application for a Corps permit. However, associated construction or structures require state and federal permits. Each of several U.S. agencies which may become involved in major projects has its own rules by which environmental considerations are made for their projects. The EIS for the project is distributed to all concerned agencies and individuals for review and comment. The document is then revised by the originating agency and the final EIS stands as a collection of facts on which Congressional or permit decisions are made.

Two of the Corps dams in western Washington were constructed prior to NEPA, thus were not subjected to very stringent requirements for fish protection. A third Corps dam, Wynoochee Dam, constructed since 1969, was equipped with both upstream and downstream passage facilities.

The third area of federal input involves the Federal Power Act of 1920, which gave jurisdiction over hydroelectric projects to the Federal Power Commission (FPC). Many of the barriers to fish migration in Western Washington are FPC-licensed, although some of these were licensed some time after they were actually constructed under other agencies' jurisdictions.

The current situation for FPC licensing or re-licensing of hydroelectric projects is that the FPC must prepare an EIS under NEPA on which all concerned agencies may comment. Any FPC project must also be consistent with the State Coastal Zone Management Plan, must have Section 10 and 404 Corps permits for auxiliary projects and dredging, and must have all state permits. Concerned parties may intervene in hearings or may file official protests, but the FPC reserves the ultimate decision.

Section 18 of the Federal Power Act states that the FPC has the right to require the construction, maintenance, and operation by the licensee, at its own expense, of such fishways as may be prescribed by the Secretary of the Interior. However, most FPC-licensed dams in Western Washington lack fishways.

2. <u>Changes in downstream flows:</u>

(a) State laws - RCW 75.20.050 declares that a flow of water sufficient to support game fish and food fish populations must be maintained at all times in streams. RCW 75.20.100 requires that anyone using, diverting, obstructing, or changing the natural flow must submit plans for the project for approval by the Directors of Fisheries and Game. These laws apparently originated in 1949 and were revised in 1955. Previously, there apparently was no statutory protection of fishery resources from over-appropriation of streamflow. In fact, most of the legal codes, such as RCW 90.03 and 90.16, encourage the appropriation of water for industrial, agricultural and domestic uses, and many streams were over-appropriated years ago.

Since the enactment of minimum flow codes (RCW 90.22) in 1969, all new diversions, withdrawals, and dams are subject to consideration of downstream instream flow needs. However, RCW 90.22 in no way affected existing water and storage rights and their use. Thus, the minimum flow laws provided little relief for the fishery resource. The State Legislature enacted RCW 90.54 in 1971; it stated that the State shall retain base flows designed to protect certain instream values, including fish. However, this law also contained a grandfather clause (RCW 90.54.900) so it pertains only to recent or future activities.

Furthermore, minimum flow laws do not provide protection from abnormal fluctuations in volume of flow causing stranding, desiccation, flushing, and disorientation of salmonids and their food supply, as well as adverse changes in water quality (e.g., excessive warming), although the water pollution laws, RCW 90.48, could be applicable to the latter.

(b) Federal laws - There are apparently no federal laws which specifically protect instream flows for projects which are not under FPC jurisdiction or related to other major federal projects. There has been some suggestion, however, that the 1972 Water Pollution Control Act amendment could legally be interpreted to protect fish and wildlife from adverse man-made flow regimes.

Major public works projects, such as Corps dams, are now subject to instream flow considerations under NEPA. Previous to the 1969 Act, though, flow characteristics for fish were at the mercy of competing users.

Projects which are licensed by FPC are subjected to flow considerations. Early licenses contain some provisions for instream flows. However, knowledge of instream flow needs for fish has improved, and the new licenses contain much more stringent flow protection for fish. Under the Fish and Wildlife Coordination Act, the FPC issued orders in 1966 and 1967 which allowed for federal and state agencies to provide recommendations for flow release programs; however, FPC makes the ultimate decision. From the earliest licensing, one of the "beneficial uses" of flows was to prevent stranding, yet this is an ongoing problem in Western Washington.

3. <u>Water withdrawal intakes</u>:

(a) State laws - Laws requiring screens (RCW 75.20.040 and 77.16.220) were enacted in 1947 and 1949. Previously, no screens were required.

These laws have not been completely enforced. The Buckley diversion on the White River is not adequately screened and many juveniles are lost into the Lake Tapps system.

(b) Federal laws - There are no federal laws which directly address screening. However, considerations of screening intakes at FPC-licensed hydroelectric projects are now required as part of fisheries resource protection. Furthermore, FPC requires evidence that all projects comply with all state laws. Currently, FPC-licensed projects in Western Washington, except for the Baker River project, do not have adult spawning upstream, therefore do not have downstream passage facilities.

4. <u>Changes in substrate</u>: Flushing of silt from impoundments or dead-ending of spawning gravel by entrapment in impoundments is not addressed by either state or federal legislation.

<u>Logging</u>:

(a) State laws - The State Forest Practices Act was enacted in 1974 to, with respect to fisheries, "encourage timber production" while "affording protection to forest soils and public resources" and "achieve compliance with all applicable requirements of federal and state laws with respect to non-point sources of water pollution from forest practices" (RCW 76.09.010). The Forest Practices Act in no way restricts application of the Hydraulics Act or the Shoreline Management Act; thus, any logging activities along major streams or within streambeds come under the scrutiny of these two laws. The Department of Ecology (DOE) has direct monitoring and reporting responsibilities regarding water quality under the Forest Practices Act.

The Hydraulics Act, which was the primary protective law previous to the Forest Practices Act, is still one of the keys to protection. Yet the Hydraulics Act only speaks to activities within the streambed and many of the upland activities of logging impact fisheries habitat.

A law enacted in 1891 and still in effect, RCW 90.28.150, states that it shall be lawful to make "improvements" on any stream for logging purposes. "Improvements" included straightening the channel by cutting across sand or gravel bars and use of splash dams for moving logs downriver to the mills at tidwater.

(b) Federal laws - The Federal Water Pollution Control Act amendments of 1972, Public Law 92-500, set a national goal which provides for the protection and propagation of fish. The Act mandates that pollution caused by runoff from forest lands be controlled by 1983. The United States Environmental Protection Agency (EPA) currently monitors water quality to assess non-point source pollution.

Discharge of pollutants:

(a) State laws - The EPA and Washington state's DOE have been working cooperatively to control water pollution by 1983 under the Federal Water Pollution Control Act amendments of 1972. Waste disposal permits have been required under RCW 90.48.160 since 1955. The permit establishes the allowable constituents of the effluents and their volumes. Discharges are allowed to continue as long as the permit conditions are met. Therefore, pollutants are and will be allowed to enter streams. To ensure that water quality remains sufficient for the propagation and protection of fish, the DOE has instigated water use and criteria classes (WAC 173-201-030). The criteria set forth limits for several general parameters in each of five classes of water (DOE 1974). The objective of this system, by using permit conditions, is to maintain the specified water quality of a given waterway.

Loopholes to this major advance in environmental protection are: (1) there is no apparent goal of upgrading the quality of certain reaches which have low classifications (e.g., the Duwamish estuary);

(2) the collection of discharges into a certain reach may create adverse, temporal conditions which would be discovered only by ambient monitoring; (3) ambient monitoring of water quality is sporadic and instantaneous rather than continuing; (4) violations of the criteria which occur during an unsampled period (the majority of the time) go unnoticed and fish are lost; (5) the conditions of the permit are specific in the number of parameters considered; if an additional unpermitted constituent is discharged, there is no record unless it is discovered in the sampling procedure; and (6) there are many discharges, especially domestic, lacking permits and the sources of which are unknown.

Previous to the permit system enacted in 1955, there was apparently no protection for anadromous fish from pollution of the state's waters.

(b) Federal laws - Under the 1972 Water Pollution Control Act amendment, the EPA has established a permit system (NPDES) for all discharges of waste waters into navigable waters. The system is essentially the same as that described above. One exception is that permittees must voluntarily submit the number of times their effluent has been in excess of the permit conditions. The EPA is also engaged in compliance monitoring to be sure the self-reporting of the permittee is reliable.

The intention of the EPA, from which the state derives its direction as well, is to bring discharges under the best practicable control technology currently available by 1977, and the best available technology economically achievable by 1983. Thus, the arrangement does not prevent discharge of pollutants because all water quality goals are effluent-oriented rather than resource-oriented.

Channel and intertidal alterations:

1. Flood control and channelization:

(a) State laws - RCW 85.05, originally enacted in 1895, authorized the establishment of diking districts. RCW 85.05.082 granted all right, title and interest in the beds and shores of any waterway within a diking district which became abandoned due to the diking to that diking district. RCW 85.05.230 authorized stream alterations to prevent the erosions of dikes. RCW 85.06.390 and 85.24.280 authorized the "improvement" of any stream or waterway within a drainage district. RCW 91.08.010, enacted in 1911, authorized any county or adjacent landowner to "improve" waterways in adjacent swamps for commercial purposes. Thus it is evident that for some time the state policy was to encourage the alteration of natural rivers and estuaries.

The Hydraulics Act was designed to prevent riverine alteration and to protect fish habitat. However, the hydraulics approval system allows for flood control work with specifications designed to protect the fishery resource. Also, the Hydraulics Act includes the provision that, in case of emergency, authorized representatives of the Washington Departments of Fisheries and/or Game may grant an oral approval to a riparian owner or lessee for removing obstructions, repairing existing structures, or restoring streambanks. Thus, piecemeal exceptions are possible. Individual activities allowed can, in the aggregate, be very harmful. Small streams in urban areas, for example, can be ultimately ruined for fish production because, over the years, each owner removes bankside cover and alters the channel due to varying individual contingencies.

(b) Federal laws - The diking and channelization of streams for flood control and navigation has been greatly encouraged by the federal government. The Watershed Protection and Flood Protection Act (Public Law 83-566) has been steadily implemented and expanded since first approved in 1954. The program is administered by the U.S. Soil Conservation Service and is authorized to provide technical, financial, and credit assistance to local sponsoring organizations in planning and installing works of "improvement" in watersheds of less than 250,000 acres. Western Washington projects, completed and proposed, include multipurpose channel work, diking, and discharge structures. All work done under these projects is required to meet all state laws. However, such projects are subject to the same deleterious piecemeal, fragmentary but incremental losses of habitat as occurs under the State Hydraulics Act. On the other hand, some features of some projects, off-stream storage and release impoundments, could help improve salmon habitat. These projects would also be subject to Corps Section 10 and 404 permits.

Traditionally the major flood control works agency, the Corps now apparently restricts its flood control activities mostly to maintenance dredging and dams. The Corps has federal responsibility for fish and wildlife resources in navigable waters, as described in the section on dams and diversions, and therefore reviews channelization and diking projects.

2. <u>Gravel removal</u>:

(a) State laws - The Hydraulics Approval system is designed to protect salmon and steelhead from gravel removal operations. Some rivers are still extensively mined for gravel. The Hydraulics Approvals contain certain provisions for gravel removal operations. However, the provisions do not control the total volume of material removed. The mere removal of portions of gravel bars, even those normally out of water, is detrimental to the habitat because these bars serve as reservoirs of spawning gravel and as stabilizers of the system.

(b) Federal laws - The Corps is responsible for issuing permits for gravel and sand removal from navigable waters. Previous to the ecological mandate of 1970 to the Rivers and Harbors Act, the Corps showed little interest in such work. Since 1970, it has been much more active in this area.

3. Dredge and fill: Dredge and fill activities include actual dredging, the disposal of dredging spoils, filling wetlands or intertidal zones, and the construction of structures, causeways, dams, dikes, levees, artificial islands, and sanitary land fills in or directly adjacent to navigable waters.

(a) State laws - The Hydraulics Act addresses the foregoing activities in estuarine and riverine areas. Previous to this Act, there was no specific protection of the resource from dredge and fill activities. Apparently, the Hydraulics Approval System is now protecting the resource against indiscriminate alteration of channel or beach areas. Guidelines of the Shoreline Management Act (WAC 173-16) recommend that dredge and fill and related activities be accomplished so that they "will minimize alterations of the natural shorelines"; they do not state that detrimental activities be eliminated.

(b) Federal laws - The Corps has had historical responsibility to protect fishery resource from dredge and fill operations in navigable waters. The resulting effort, aside from obvious obliquitory obliteration of habitat, has been compromised by being largely unable to predict interactive and integrative impacts of projects. Strategic and tactical planning at the ecosystem level requires information well-suited to the needs of engineers and other scientists of the older disciplines. Up until recently, ecologists have not been able to supply practical remedies to largely theoretical but real problems.

Inadequacies of the legal system:

The inabilities of the state and federal legal systems to protect fishery habitat are rooted in several causes. The first is the inadequacy of the laws themselves; they do not prevent destruction, both gross and subtle, of all the intricate parts of the aquatic ecosystem. The laws are usually stated in terms too general to adequately address all the complexities. This vagueness leads to many loopholes in enforcement.

Second, the agencies which are designated to implement legislation often find themselves unable to do so because of a lack of resources, the weakened legal position mentioned, and/or political ambivalence. Often costs of effective enforcement, monitoring and data gathering are underestimated, resulting in severe constraints on agency manpower and equipment.

Invariably all government agencies are forced to develop middle-of-the-road philosophies in a democratic society most influenced by special interest groups. Ambivalence is excruciated with the usual multiple objectives of government -- it is being kept in mind that there is usually no priority implied in the order of objectives, that there are interactions in the objectives, and that trade-offs and compromise will be necessary. Multiple goals are striking in implying that there can be no single optimum policy, for as we all know, one cannot optimize for two things at the same time, let alone a dozen, i.e., maximize food production, preserve ecological balance, provide for economic viability and growth, etc. Accordingly, it can only be deduced that salmonid habitat has largely been altered out of deference to higher societal priorities, at least up until this juncture in history.

Third, laws were enacted only after the resource began to diminish. Crisis-invoked legislation invariably involves much shooting from the hip.

Fourth, some laws may be difficult or impossible to enforce. For example, the laws requiring effective fishways in dams were at one time technically impossible to comply with.

The Hydraulics Approval System, now the key protection for fish habitat in Washington, illustrates the dilemma of much of the pioneer and progressive environmental protection of the state. There is lack of awareness by private corporations, public agencies, and private individuals that a permit is required to do work in a streambed. Convictions are difficult to obtain, and when favorable judgments do occur, the penalties are often too slight to provide deterents. Sheer volume of applications and lack of staff precludes thorough monitoring for violations. Federal programs likewise suffer from inadequate funding, quixotic jurisprudence, and public lethargy. In the final analysis, institutions only minor the collective will of the people, thus, the villian, if there must be one for spilt milk, is us, all of us.

POLICY FRAMEWORK FORMULATION

Population increases association with increased industrialization and urbanization present numerous problems and conflicts affecting salmonid habitat. Greater demands for more fish and diminished habitat potential are implicit in such destiny. It also follows that society possesses a technical and economic capability which drastically outpaces social wisdom. In almost all human endeavors, we respond to a need of society with a program which changes the character of whatever we are trying to manage. This change has an impact upon the desires and needs of the public which in turn influence future management. And so we have tracked through history, trying to manage our resources -- land, water, forests, mineral, fish -- to match social trends and, often inadvertently, generating new trends and conflicts in the attempt.

The out-of-control nature of the process has been recognized in the environmental movement of recent years. Accordingly, there has been increasing emphasis in understanding man's and nature's world as a functional whole. The same should apply to habitat of salmon and steelhead, away from mere component analysis, wherein factors and organisms are treated as if they were independent entities, to more holistic approaches which include interactive, integrative and emergent properties of watersheds, the basic ecosystem unit.

Broad conceptual understanding and balancing of resource capabilities with conflicting human needs requires identification and quantification of values, generating sound philosophy in appropriate sectors of society, and integration with biological technology in effective, foresighted planning and management.

The problems of this approach in fishery management can be made clearer by the potential conflict between artificial and natural enhancement. It has been estimated that approximately 80% of the salmon produced in the state still originate naturally. Theoretically, it is possible to eclipse the yield of natural fish with massive stocking of hatchery fish, and, in so doing, with some species, in some situations, virtually eliminate natural reproduction.

Salvation from the spiralling demand for salmon and steelhead and pending loss of habitat, implicit in the onslaught of historical development and growth of the region, clearly negates against a philosophy of either maintenance of the status quo or development, hatchery or wild fish, or the application of opiate laws. The clock can neither be turned back nor arrested. What is needed is the understanding necessary to describe and relate all the elements affecting salmonid management -- the hydrologic, biologic, geophysic, economic, political, legal, and social systems and their interaction with each other. Habitat preservation and enhancement are vital pillars of such planning, as is the stocking of hatchery fish in habitats that have been irrevocably altered, or in response to other demonstrated need and advantage.

The purpose of this report is not to elucidate all the influences affecting salmonid abundance, although some of the more pressing habitat interrelationships and needs have been described. Nor is it our purpose to describe and evaluate the methods, technicalities and effectiveness of planning, legislation, or fisheries management, though we make some observations under these headings. Nor is it a planning product, an irrelevant map, plan, blueprint, which cannot be intimately related to the plethora of political decision-making entities that control the destiny of salmonid habitat. Long-range solutions to problems of resource supply and environmental quality in a dynamic economy and society require technical responses long in gestation and complicated to bring forth. A stable policy framework consistent with long-term needs is absolutely essential to such direction, as already illustrated by failure or debilitation of much past legislation. Here we concentrate on preservation and enhancement of salmonid habitat, its meaning, the forms it takes, and some of its implications pertinent to such commitment. Policy implementation then can take any of several forms.

Today there are many users and many uses of watersheds. The principle of multiple use for the public benefit is paramount, but many uses are to some extent mutually incompatible and tough decisions must be made about the "mix" of benefits to be reaped from a watershed. This has led, naturally enough, to an increased emphasis on public involvement in policy and management decision-making. This involvement, in turn, raises the very real problem: "Who is the public?"

Can the people of Seattle justifiably override the wishes of the people of Washington if their interests do not coincide on a management issue in the Skagit Valley (e.g., additional electric power and fewer salmon)? More dramatically, who should control the development of oil ports on Puget Sound -- Washingtonians or the nation? Obviously, there is no clear resolution of this problem -- national interests cannot wholly override state interests, and it is equally unrealistic to expect state interests to override the national interest. A compromise is going to have to be reached.

At the national level, planning also involves the general economy. To what extent should the economy be planned? Our economic heritage is the so-called free market system, but we have never had completely free markets. What is the optimum mix between freedom and control?

It should, of course, be noted that planning and control are not synonymous. Planning need not involve strict control; it can take the form of incentives, indicators, public education and other voluntary measures to achieve some degree of tacit or expressed agreement on goals and actions. But planning does necessarily imply an attempt to change a course of events from what would otherwise have occurred without intervention.

FORMS OF POLICY IMPLEMENTATION

Environmental legislation: The Washington Departments of Fisheries' and Game's Hydraulic Permits Approval System, the State's primary protection for salmonid habitat, could be upgraded. Current inadequacies apparently stem from rather weak interpretation and implementation of the law (RCW 75.20.100). Correctional changes proposed are: (1) upgrade the special and technical provisions of the Approvals to better protect the habitat; (2) extend the area of consideration to beyond the streambed for certain activities such as forest practices; (3) increase funding to enable stricter monitoring and greater detailed review; and (4) to address each proposed project systematically in relation to all other projects and be more closely attuned to the interrelationships involved, thereby minimizing piecemeal, fragmentary but incremental losses of habitat.

The Corps of Engineers permit and project review processes are the primary federal protection involving salmonid habitat. Generally acknowledged improvements needed are: (1) greater emphasis on education about, and enforcement of, the Corps' permit system; (2) addressing each project systematically in relation to all other projects; (3) funding for all participating agencies adequate to the task; and (4) that agencies whose primary responsibilities are to the fishery resource should have equal decision-making capability with the Corps or other development agencies in regard to measures necessary for protection and enhancement of the resource in Corps-permitted activities or major public works projects (example: a bill to so amend the Fish and Wildlife Coordination Act, Appendix 3).

Major habitat benefits would accrue from wiser use of flood plains. Preferrably, it would seem, the Flood Control Zone Act (RCW 86.16) should be amended to include the ability for the DOE to prohibit construction on flood plains. If the building of residential, business and agricultural structures was limited, especially on land abutting streams, the need for riprapping and channelization, two of the most severe habitat alterations, would be greatly reduced. On the other hand, such a strict law could be unrealistic. There is fallacy in putting too much weight on laws or regulations without thoroughly examining more flexible ways of achieving their purpose. For example, it is doubtful whether people would build in hazardous flood plains if they knew government or the private sector would not rush to their relief in times of disaster with flood control works, insurance, or other aid.

Habitat improvement and maintenance: Fish production potential above present fish passage barriers in streams within the Puget Sound and coastal regions is substantial. Realization of potential can be accomplished either by removing or by-passing migration blocks to allow natural spawning and rearing, or by instituting stocking programs that allow utilization of the available rearing potential above the block. Many barriers can be by-passed by installing fish ladders or by placement of adult fish trap-and-haul facilities. Many barriers, particularly man-made structures, such as hydroelectric dams, require screening and by-pass facilities for getting downstream juvenile migrants safely around or over such barriers. Major opportunities for opening new salmonid production habitat are located in the Puyallup, Hood Canal, Lake Washington, Elwha, and Duwamish watersheds. A parallel problem is removal of accumulations of logging slash debris in water courses that either cause a block to fish migration or severe bank erosion.

Damaging floods and unstable streamflows can be eliminated or mitigated on major streams having otherwise good salmon production potential. Flood control and flow stabilization measures include storage impoundments, either on upper reaches of mainstem rivers or in off-river storage areas of little or no value as salmonid habitat; flood flow diversions with piping or canal systems; or placement of high water overflow channels in critical areas. Naturally-occurring low summer flows, common to at least some stretches of virtually every river drainage, can usually be increased only by release of water from impoundments. Flood control would be particularly beneficial for streams in the Nooksack, Skagit, Snohomish, Hood Canal, and Lake Washington watersheds. It has been estimated that over 660 miles of streams in the Puget Sound region could be enhanced by such projects. On the coast, the Chehalis River has potential for flood control benefits.

Assuming major flooding is controlled by upstream or off-river storage and release impoundments, major consideration logically should then be directed to restoration of straightened, channelized river sections. As already inferred, flood control measures involving channel shortening and deepening through dredging and revetments, represent, at best, only a temporary adjustment between the hydraulic forces involved. The cutting power of the water is vastly increased by such flood control measures, due to concentrating effects not unlike those produced by a hose nozzle, and it is only a matter of time until the river literally explodes in the same or a new direction. Of course this brings into play the counter forces of more man-made channelization, and the process can only end when the flows can be fully contained in concrete and steel -- not a likely prospect for major waterways. Restoration, accordingly, should focus on lengthening by designing all the meander possible into the new water course. In this dispersion of energy, advantage should be made of any old meanders and oxbows. This is important in reducing torrential discharge and velocity limiting living space for salmonids in high-gradient streams. Barring such idealist effort, the placement of large boulders in chute-like channelized river sections could also provide greater occupancy for salmonids.

Rapidly fluctuating changes in stage (not simply a high volume of discharge) or extreme low flow conditions occurring as a result of hydroelectric power peaking, flood control, or irrigation projects, could be better regulated to provide the necessary conditions for fish transportation, spawning, and rearing. Most needed in the coordination and negotiations requisite to achieving least damaging flows is quantified knowledge of instream production within and between the various water regimes possible in a given circumstance.

Streams suffering from unstable streambeds, imbalances of spawning and/or rearing habitat, or associated limiting factors, can be improved by well-thought-out habitat improvement projects. Streambeds can be stabilized through the placement of submerged weirs or bed controls at strategic locations. Techniques for cleaning silt from gravel beds and/or replacement of gravels have been developed in recent years and show much promise for rehabilitation.

The ultimate solution to the silt-sediment problem, of course, lies in improved land-use. Fortunately, the forest products industries, which have been principal polluters in the past, show increasing promise of amending causative logging practices. Not to be overlooked is that: logs and fish need not be mutually incompatible benefits of watersheds; private and public forest lands constitute the great bulk of watershed areas in Western Washington, with many key headwaters set aside in National Parks; it is perfectly feasible for the controlling entities to effectively plan for such systems; and the technology is available to reduce the impacts of logging on salmonid habitat. Some of the more promising ameliorations include: (1) helicopter and balloon skyline logging; (2) improved road location; (3) streamside buffer strips; (4) tree jacking and pulling away from the stream when operating in the riparian zone; (5) end hauling of road construction wastes; (6) use of crushed rock and asphalt on road surfaces; and (7) seeding of exposed road cuts.

Teams of fisheries biologists, engineers, and hydraulic investigators comprise four projects within the WDF dealing with habitat management. The freshwater habitat protection and marine habitat protection units are responsible for project reviews, assessments, and permits. The hydrology unit performs instream flow studies and review of surface water right applications. The fourth unit develops and recommends fish protective and mitigation features to be incorporated in large dam, nuclear, water diversion, and screening projects.

During the 1977-79 biennium, the Washington Department of Fisheries anticipates doing stream clearance work in approximately 90 stream areas, streambed rehabilitation in 47 locations, natural egg incubation at 28 projects, and fish passage maintenance at 270 sites.

Education: It has been repeatedly emphasized that the synthesis which is fisheries management rests with professional fisheries biologists. The job is enigmatic, and has been described as living in a demanding world of gray where black and white certainly is the exception. From this edge of uncertainty, values must be identified, quantified and generated in society so as to permit the conception and application of scientific knowledge concerning fish populations and habitats. The requisite skills and aids straddle the professions of teaching and medicine. In education the student is brought around by satisfaction, punishment, prize, disapproval, acclamation, communication, image, whereas in medicine the patient is treated by dent of scalpel, chemical, machine or benign neglect.

From this introduction it should be clear that education can take many forms, ranging from better informing the private individual for the reason and need for obtaining a hydraulic permit to do work in a stream, to the controversy surrounding the Boldt decision. Basic to such thrust is Aldo Leopold's land-use ethic of proper stewardship, recognizing that ecosystems are extremely complex and that the present nominal titleholder is but a transient visitor. Unfortunately, such bottom line considerations are generally occluded in the real urban world where most people live.

Modern technology, while providing a better material existence, has taken a heavy toll on the urban habitat. Asphalt and concrete have replaced sod and trees. Rivers and streams are fouled. Wires, buildings and billboards clutter the horizon. The delicate pleasures and mysteries of nature have given way to the noise and fumes of mechanization. Milk no longer originates from a cow but from a supermarket.

River restoration on a model or demonstration basis suggests a way to reverse the process of environmental degradation and reintegrate nature into the urban fabric. A restored urban river can provide a focal point for inner city revitalization and find ways to live with conflicting uses.

Denver, Colorado's Platte River Greenway Project is an example of attempts at such re-integration, an experimental "de-mechanized zone" in the heart of the city. The Greenway Project aims to restore the entire 10-mile reach of the Platte River through Denver, a first step in creating a region-wide open space corridor extending from the Platte's source waters, in the mountains nearby, downstream to the limits of the metropolitan area.

Research: A major federal thrust is on the side of research, not necessarily in-house or centralized, but government-sponsored. For years the federal government has affected resource supply through research on agricultural problems, and the federal role in incubating nuclear energy resources has been prominent. Many other significant contributions could be cited. In the area of environment, federal efforts have either had the routine character of much Geological Survey work or have been oriented to fairly specific problems such as the efforts of the EPA. Accordingly, a modest but comprehensive and systematic program aimed at anticipating future stress to salmon habitat and ways to combat it in the real world could spare both the environment and much investment cost considering economies of scale.

For example, there remains unanswered questions concerning the use of herbicides and pesticides in forest management and the effectiveness of fish passage facilities at dams. The possible definitive impacts, negative and, possibly, positive, of logging on salmon habitat largely remain to be elucidated. The apparent decline of steelhead trout in recent years represents unresolved phenomena, yet the techniques and money required for diagnosis and prescription are wanting. Although relationships between biological and physical requirements of fish are well recognized, interactions between factors that make up the stream environment are so numerous that expression of these relationships in quantitative terms is currently next to impossible.

The science of ecological engineering and therapeutic ecology is only in its infancy. Until such time as we learn enough about natural stream ecosystems and are capable of quantitatively evaluating alternative management options, whether it be instream flow regimes, habitat improvement, or holistic cost-benefit ratios, preservation and/or restoration for fisheries cannot be expected to equitably vie with conflicting uses. Reliable and comprehensive information in a number of other areas is integral to model river restoration as well. Any accommodation between man and nature lies in extending the utility of existing finite resources using the very technology, epitomized by the bulldozer and the computer, causing the discord.

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